PIER Energy-Related Environmental Research
Environmental Impacts of Energy Generation, Distribution and Use

Assessment of Nitrogen Deposition: Modeling and Habitat Assessment

Contract #: 500-99-013
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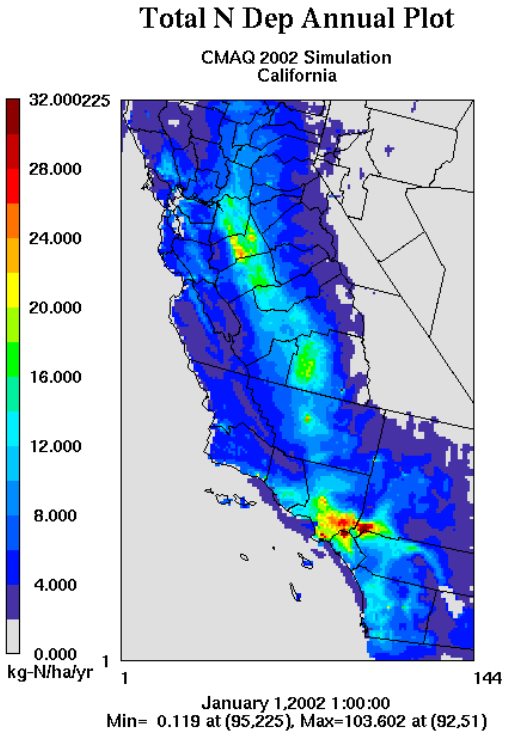
The Issue

All Californians contribute to the state's nitrogen emissions; whether by driving to work, eating a meal, or using electricity. These nitrogen emissions (a component of "acid rain") are the result of fossil fuel combustion, and in the West the three major producers of nitrogen emissions are transportation, agricultural production, and industrial activities-including electricity production.

Nitrogen emissions in California have decreased over the last 20 years, but ecosystems within the South Coast air basin receive the highest nitrogen deposition in the country (25 to 45 kilograms per hectare per year), and can exceed 90 kg/ha/yr.[1] These emissions not only result in higher ground-level ozone (because nitrogen oxides, or NO_X, play a major role in the formation of ozone), their deposition on land or in aquatic environments can degrade sensitive ecosystems. In fact, ecosystem structure and diversity can be negatively affected by nitrogen concentrations as low as 3 to 8 kg/ha/yr.[2] Nitrogen deposition can cause decreased plant function, promote exotic species,[3] and leach into surface and ground waters, which can lead to



Community Multiscale Air Quality modeled distribution of all types of nitrogen deposition in California for 2002.

[1] PIER-EA Agreement with the University of California, Santa Barbara, and the University of California, Riverside, to Assess Nitrogen Deposition Models and Habitat Impacts in California. September 12, 2003.
[2] Ibid.
[3] For example, during the Metcalf Energy Center siting procedure, one analysis concluded that non-native grasses would use the additional nitrogen more effectively than native grasses, and thereby overtake the native grasses, and that as little as 5 kg/ha would spur that conversion. (Scholz, Scott. October 27, 1999. Community News. California Energy Commission Biological Issues Workshop for Metcalf Energy Center. www.energy.ca.gov/sitingcases/metcalf/documents/intervenors/2000-02-08_community_news.html.

accelerated algae growth and oxygen depletion in recipient water bodies.

Power plants release NO_X, nitrogen dioxide (NO_2), and ammonia (NH_3), which is deposited in local and downwind habitats.[4] In 2002, California's electric utilities (excluding cogeneration plants) emitted over 62 tons per day of NO_X. To address this source of nitrogen deposition, power plant licensing procedures consider the impacts of nitrogen deposition on air quality and terrestrial and aquatic ecosystems in their environmental reviews.[5]

During these reviews, air dispersion models are used to model nitrogen deposition quantities during power plant construction and operation. However, many air dispersion models are available for use, and currently it is unclear which one may represent nitrogen dispersion most accurately. There are concerns about the models' ability to forecast both short- and long-range deposition values, and about the tendency for worst-case-scenario assumptions to be used to produce the most conservative impact scenarios.

A comparative assessment of models and other factors that affect nitrogen deposition and its affect on California is necessary to improve confidence in these evaluations and to protect habitats and species that may be particularly sensitive to such deposition. Energy Commission siting staff has an immediate need for this type of analyses for two important reasons: (1) nitrogen emission impacts to air quality are evaluated for every power plant application, and (2) ecological impacts of nitrogen deposition have been a concern on a number of recent power plant siting cases.[6] The issue is expected to be an increasing concern because of recent work indicating that nitrogen deposition can have severe impacts on ecosystem function and integrity.

Project Description

In this project, PIER-EA funded work by the University of California at Riverside to better characterize and quantify the impact of nitrogen deposition on California's ecosystem health. Researchers reviewed and compared the air quality models used to determine power plant nitrogen emissions and conducted a chemical analysis of power plant plume characteristics, including the reaction rate from gas to particulate.

Model assessments included an evaluation of their ability to characterize the chemical form of the nitrogen, because the emission's chemical form affects its deposition velocity and transport range. Researchers compared the ISCST3, AERMOD, CALPUFF and CMAQ (Community Multiscale Air Quality) models under several different meteorological scenarios and selected one model to use for an annual simulation, which will provide estimates of nitrogen deposition for a variety of meteorological and seasonal conditions. They performed a baseline estimate using 2002 NO_X and NH_3 emissions and ran a sensitivity case to evaluate the effects of adding new nitrogen emissions sources at selected locations.

[4] PIER-EA Agreement with UC Santa Barbara and UC Riverside to Assess Nitrogen Deposition models and Habitat Impacts in California. September 12, 2003.
[5] Ibid.
[6] The Metcalf Energy Center Power Project, Otay Mesa Generating Project, Pico Power Project, and Los Esteros Critical Energy Center.

Energy Commission siting staff and California Air Resource Board representatives were instrumental in developing this research.

PIER Program Objectives and Anticipated Benefits for California

This project offers numerous benefits and meets the following PIER program objectives:

- **Providing environmentally sound energy.** By identifying the most accurate model for nitrogen deposition, this project improves Energy Commission staff's ability to assess impacts from power plant construction and operation, thereby further enhancing their ability to make informed choices about power plant siting and to protect endangered habitat and species. Improved understanding of nitrogen deposition models will support the development of better policy and management.

- **Providing reliable and affordable energy services.** Power plant licensing decisions require accurate data on a host of environmental subjects, any one of which may delay or derail the process. Identifying the most accurate nitrogen deposition model will help speed the licensing process and facilitate a more accurate assessment of deposition levels, which will result in fair mitigation requirements for power plant developers. As a result, much-needed power generation should be built more quickly, and at a lower cost.

Results

This study tested ISCST3, AERMOD, CALPUFF, and CMAQ for modeling nitrogen deposition. The CALPUFF model is the best choice; however, none of the models tested were deemed adequate. The researchers recommend that new-generation photochemical grid models be evaluated.

The most significant result is the development of the CMAQ model-simulated baseline annual nitrogen deposition on a 4-kilometer resolution grid. Researchers also developed a comprehensive 2002 emissions inventory for the 4-km grid. These results are valuable in studying nitrogen deposition effects on sensitive ecosystems, in developing guidance to mitigate the effects of nitrogen deposition from new power plants, and to preserve California's unique ecosystems.

A workshop presenting research results was held at the Energy Commission in December 2006. For more complete project details, go to: http://pah.cert.ucr.edu/aqm/ndep.

Final Report

This project's final report is *Assessment of Nitrogen Deposition: Modeling and Habitat Assessment.* It is posted at the California Energy Commission website, at www.energy.ca.gov/pier/final_project_reports/CEC-500-2006-032.PDF.

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